Cancer Causes and Control **14**: 587–593, 2003.

Cancer incidence among male Swedish veterinarians and other workers of the veterinary industry: a record-linkage study

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Received 30 August 2002; accepted in revised form 30 March 2003

Key words: cancer incidence, epidemiology, occupational exposure, veterinarians.

Abstract

Objective: To investigate the risk of cancer among veterinarians in a large record-linkage study from Sweden.
Methods: We used the nationwide, Swedish Cancer Environment Registry III, which links the Cancer Register data for 1971–1989 to the national population censuses from 1960 and 1970, to compare the incidence of cancer among male veterinarians to that of the remaining part of the active population using multivariable Poisson regression models and standardized incidence ratios. One thousand one hundred and seventy eight men classified as veterinarians or workers in the veterinary industry at either census were identified.
Results: Veterinarians in the veterinary industry experienced increased risk of esophageal (relative risk (RR) 3.78, 95% confidence interval (CI) 1.42–10.09), colon (RR: 2.36, 95% CI: 1.42–3.91), pancreatic (RR: 2.10, 95% CI: 0.94–4.68) and brain (RR: 2.51, 95% CI: 1.04–6.03) cancers as well as melanoma of the skin (RR: 2.77, 95% CI: 1.24–6.17). Similar excess risks were observed when veterinarians were compared with individuals of similar socio-economic status.
Conclusion: The increased risks of esophageal, colon, pancreatic and brain cancers as well as melanoma observed among veterinarians did not seem to be explained by the high socio-economic status of this occupational group. Therefore, it is possible that some of these results reflect the carcinogenicity of occupational exposures, including animal viruses, solar or ionizing radiations and anesthetics.

Introduction

Veterinarians are exposed to possible carcinogens including radiation, pesticides, anesthetics and zoonotic viruses [1, 2]. A limited number of studies have assessed cancer risks in this occupational group. We are aware of six relevant cohort studies. Five of them were conducted in the United States (one of them [3], which includes 5016 white male veterinarians, overlapped the four other studies [4–7]) while the sixth included a total of 3440 veterinary surgeons resident in Britain [8]. Significantly elevated risks were found in the United States cohorts for all cancers combined [4], cancers of the colon [3, 4], skin [3, 4, 6] and brain [3], and all lymphohaematopoietic neoplasms [3], but none of these elevated risks were confirmed in the British study which found no excesses of any form of cancer. All the studies analyzed mortality, which might reflect survival in addition to incidence, particularly for cancers with good prognosis [9].

Data from a nationwide linkage between Swedish censuses and cancer registry provide a large population of veterinarians among which cancer incidence can be investigated.

The purpose of this study is threefold: (1) to estimate cancer risks among veterinarians based on incidence, (2) to compare the cancer risks of veterinarians with those of individuals of similar socio-economic status, and (3) to discuss whether the results observed in a large

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European cohort of veterinarians are comparable with those observed among United States veterinarians.

Materials and methods

In 1960 and 1970, two National Population and Housing Censuses were conducted by Statistics Sweden. For all individuals living in Sweden, information on place of residence, demographic characteristics, employment status, job title and industry were collected through questionnaires. Individuals were followed for cancer incidence and mortality from January 1971 to December 1989 through linkage with the National Register of Causes of Death and the Swedish Cancer Registry. From these linkages, the Cancer Environment Registry III (CERIII) was created.

Each cohort member contributed person-years of observation from 1 January 1971 until death or end of follow up (31 December 1989), whichever occurred first. For the purpose of this analysis, our interest was focused on males who, at either the first or the second census, worked as veterinarians (Swedish occupational code 021) or were employed in veterinary medicine (Swedish industry code 015). A total of 1178 men classified as veterinarians or workers in the veterinary industry at either census were identified, 701 of them were veterinarians in the veterinary industry. Women were excluded from this analysis since they represented less than 10% of the relevant occupational group. The workers who retired between 1960 and 1970 were included in the cohort. Subjects in the cohort were classified according to residence in one of four main regions of the country (Most Northern, Northern and Middle, Southern and Most Southern) and residence in a large urban area (Stockholm, Gothenburg or Malmo) *versus* the rest of the country.

We created four groups of exposed subjects. First a broad group with individuals classified with either the relevant occupational code or the relevant industry code. Within this heterogeneous group, comprising veterinarians employed in different industries and other workers of the veterinary industry, three more specific groups were defined. 'Veterinarians in the veterinary industry', 'veterinarians in other industries' including those working in butcher shops, meat processing or packing, agriculture, education, health care and research (Table 1), and finally, 'workers other than veterinarians in the veterinary industry' including primarily agricultural, horticultural and livestock workers (Table 2). The

Table 1. Frequencies of industrial groups among veterinarians (Swedish occupational code 021)

Industrial groups	1960		1970	
	n	%	n	%
Veterinary medicine	459	71.7	531	72.0
Butcher shops, meat processing or packing	56	8.8	53	7.2
Services (defense, administration)	41	6.4	11	1.5
Agriculture	38	5.9	46	6.2
Education	34	5.3	38	5.1
Health care and research	6	0.9	38	5.1
Other	6	0.9	21	2.8

n, Frequency.

Table 2. Frequencies of occupational groups among employees of the veterinary industry (Swedish industry code 015)

Occupational groups	1960		1970	
	n	%	n	%
Veterinarians	459	65.0	531	84.8
Agricultural, horticultural and livestock work	168	23.8	43	6.9
Technical, chemical, physical and biological workers	19	2.7	14	2.2
Clerical workers	11	1.6	2	0.3
Precision toolmakers	8	1.1	10	1.6
Health and medical workers	1	0.1	10	1.6
Other (business managers, building caretakers, messengers…)	40	5.7	16	2.6

n, Frequency.

workers employed as veterinarians in other industries at one census and as non-veterinarians in the veterinary industry at the other census were excluded from the three more specific groups. These subjects provided only 26 person-years of observation, less than 0.2% of the broad exposure group.

Since veterinarians are quite a stable occupation (82.6% of the subjects recorded as veterinarians at the first census were recorded as veterinarians at the second census), we did not restrict the analysis to the individuals having the same occupation at both censuses. Such a restriction would have excluded the veterinarians who retired between the two censuses.

Standardized incidence ratios (SIR), defined as the ratio of the observed to the expected cases were calculated for all neoplasms combined and for specific neoplasms. The expected numbers of cancers were obtained by applying the national rates stratified by five-year age and calendar year group to the cohort studied. Ninety five percent confidence intervals (CI) were calculated assuming that under the null hypothesis the observed number of cases follows a Poisson distribution [10]. Second primary cancers were included in the calculation of both observed and expected cases.

Multivariate analyses based on a Poisson regression model were conducted on the occurrence of selected types of cancer among veterinarians as compared to the rest of the employed male population included in CERIII, after exclusion of the other occupational groups whose job entails extensive contacts with animals: breeders, hunters and butchers. The unexposed population contributed a total of 40,220,196 person-years of observation. Stratification variables (five-year age groups, four-year calendar periods, residence regions and urbanization levels) were introduced in the multivariate regression models. Second primary neoplasms were excluded from this analysis; the follow-up of subjects was truncated at the date of the diagnosis of the first cancer. Relative risks (RRs) and 95% CI were calculated for each exposure subgroup. The number of person-years contributed by men classified in each category at either the first or second census was 19,060 for the broad group of individuals classified with either the relevant occupational code or the relevant industry code, 11,019 for veterinarians in veterinary industry (57.8% of the broad group), 2970 for veterinarians in other industries (15.6%) and 5046 for workers other than veterinarians in the veterinary industry (26.5%).

In addition, as several cancers are known to be associated with socio-economic status, multivariate analyses based on Poisson regression modeling were also conducted by comparing veterinarians to the rest of the employed male population of high socio-economic status at either the first or second census (6,617,808 person-years of observation). The definition of this group, which included technical, chemical, physical and biological technicians, engineers and researchers as well as doctors, legal professionals, literary and artistic workers, business managers and ship and aircraft pilots and engineers, was partially based on a classification used by Statistics Sweden [11].

Results

The standardized cancer incidence ratios of men identified as veterinarians or other workers of the veterinary industry in 1960 or 1970 are reported in Table 3. As compared to the experience of the national population significant increases were observed for malignant melanoma of the skin (SIR: 2.86, 95% CI: 1.43–5.13) and for colon cancer (SIR: 1.86, 95% CI: 1.14–2.88) while an almost significant excess was detected for prostate cancer (SIR: 1.34, 95% CI: 0.97–1.80). Non-significantly elevated risks (SIR $>$ 1.50) were found for esophageal, pancreatic, eye, and brain cancers as well as chronic lymphocytic and non-lymphocytic leukemias.

Table 4 shows selected results of the regression analyses of subjects employed in the three more specific exposure groups. As second primary cancers were excluded from this analysis we observed 153 cancers instead of 170 (one of the 153 cancers does not appear in Table 4 because it was experienced by a subject with the relevant occupational code at one census and the relevant industry code at the other census). An increased incidence of melanoma of the skin was found in all three subgroups. These neoplasms arose mainly from the trunk (five such cases were found among veterinarians employed in the veterinary industry, RR: 4.80, 95% CI: 1.99–11.55, result not shown).

A significant increased risk of colon cancer (RR: 2.36, 95% CI: 1.42–3.91) was found among the veterinarians in the veterinary industry while slight deficits were observed in the other groups. Individuals in the first group experienced elevated incidence of cancers of the caecum and ascending colon (six cases, RR: 2.84, 95% CI: 1.28–6.33), transverse colon (three cases, RR: 3.68, 95% CI: 1.18–11.42) and of sigmoid colon (five cases, RR: 2.28, 95% CI: 0.95–5.47) while no cases of descending colon were observed in this group (results not shown).

The veterinarians in the veterinary industry experienced an increased incidence of esophageal (RR: 3.78, 95% CI: 1.42–10.09), pancreatic (RR: 2.10, 95% CI: 0.94–4.68) and brain (RR: 2.51, 95% CI: 1.04–6.03) cancers as well as the veterinarians in other industries,

Table 3. SIR of selected cancers among male veterinarians and employees of the veterinary industry in 1960 or 1970

Neoplasms[a]	ICD-7 codes[b]	n	SIR	95% CI
All cancers	140–209	170	1.16	0.99–1.35
Buccal cavity and pharynx	140–148	4	0.90	0.24–2.31
Esophagus	150	5	2.61	0.84–6.10
Stomach	151	11	1.18	0.58–2.11
Colon	153	20	1.86	1.14–2.88
Caecum and ascending colon	153.0	8	2.28	0.98–4.49
Transverse colon	153.1	3	2.16	0.43–6.31
Descending colon	153.2	1	1.77	0.02–9.87
Sigmoid colon	153.3	6	1.66	0.61–3.62
Rectum	154	3	0.39	0.07–1.16
Liver, bile ducts	155	3	0.95	0.19–2.79
Pancreas	157	8	1.69	0.72–3.33
Lung	162	9	0.59	0.27–1.12
Prostate	177	44	1.34	0.97–1.80
Kidney	180	6	1.07	0.39–2.34
Bladder	181	15	1.39	0.78–2.30
Malignant melanoma of skin	190	11	2.86	1.43–5.13
Skin non-melanoma	191	3	0.48	0.09–1.43
Eye	192	1	2.59	0.03–14.46
Nervous system	193	6	1.63	0.59–3.56
Brain	193.0	6	1.75	0.64–3.81
Non-Hodgkin's lymphoma	200, 202	3	0.72	0.14–2.10
Hodgkin's disease	201	1	1.25	0.01–6.98
Multiple myeloma	203	2	0.84	0.09–3.05
Leukemia	204	6	1.48	0.54–3.23
Acute lymphocytic leukemia	204.3	0	0.00	0.00–31.24
Chronic lymphocytic leukemia	204.0	3	1.62	0.32–4.74
Acute non-lymphocytic leukemia	204.2, 204.6	1	0.99	0.01–5.52
Chronic non-lymphocytic leukemia	204.1	1	2.01	0.02–11.22

n, Number of observed cases; SIR, standardized incidence ratio; CI, confidence interval.
[a] Neoplasms are listed if three or more cases were observed, with the exception of neoplasms previously reported at high risk.
[b] Swedish Cancer Registry version of ICD-7.

Table 4. RR among subjects employed as veterinarians or veterinary industry workers at either 1960 or 1970 census – results of Poisson regression analysis

Neoplasms	Veterinarians in the veterinary industry			Veterinarians in other industries			Workers other than veterinarians in the veterinary industry		
	n	RR	95% CI	n	RR	95% CI	n	RR	95% CI
All cancers	99	1.16	0.95–1.41	18	1.01	0.64–1.60	35	1.12	0.80–1.56
Esophagus	4	3.78	1.42–10.09	1	3.99	0.56–28.34	0		
Stomach	5	0.91	0.38–2.18	0			4	2.19	0.82–5.84
Colon	15	2.36	1.42–3.91	1	0.78	0.11–5.53	2	0.89	0.22–3.55
Pancreas	6	2.10	0.94–4.68	1	1.77	0.25–12.54	1	0.99	0.14–7.04
Lung	7	0.80	0.38–1.68	1	0.52	0.07–3.66	1	0.29	0.04–2.05
Prostate	23	1.12	0.74–1.68	5	1.25	0.52–3.01	13	1.93	1.12–3.32
Kidney	2	0.62	0.16–2.49	0			2	1.62	0.41–6.48
Bladder	8	1.29	0.64–2.58	2	1.51	0.38–6.03	2	0.86	0.21–3.43
Melanoma of the skin	6	2.77	1.24–6.17	1	1.84	0.26–13.08	3	3.12	1.01–9.67
Brain	5	2.51	1.04–6.03	1	2.24	0.32–15.93	0		
Leukemia	3	1.28	0.41–3.98	0			1	1.17	0.16–8.28

n, Number of observed cases; RR, relative risk adjusted for age, calendar period, geographic region and urban setting (reference category: workers in jobs not entailing animal contacts at both 1960 census and 1970 census); CI, confidence interval.

Table 5. RR among subjects employed as veterinarians at either 1960 or 1970 census compared to the rest of the male employed population with highest income and education in 1960 or 1970 – results of Poisson regression analysis

Neoplasms	Veterinarians		
	n	RR	95% CI
All cancers	118	1.07	0.90–1.29
Esophagus	5	4.02	1.66–9.73
Stomach	5	0.91	0.38–2.20
Colon	516	1.79	1.10–2.93
Pancreas	7	2.13	1.01–4.47
Lung	8	0.70	0.35–1.39
Prostate	28	1.05	0.72–1.52
Kidney	2	0.46	0.11–1.84
Bladder	10	1.17	0.63–2.18
Melanoma of the skin	8	2.33	1.16–4.67
Brain	6	2.35	1.05–5.25
Leukemia	3	1.04	0.34–3.25

n, Number of observed cases; RR, relative risk adjusted for age, calendar period, geographic region and urban setting (reference category: non veterinarians with highest income and education in 1960 or 1970); CI, confidence interval.

while no excesses were detected among other workers in the veterinary industry. On the other hand, these workers experienced a significant increased incidence of prostate cancer (RR: 1.93, 95% CI: 1.12–3.32) and non-significant increased incidence of oral (three cases, RR: 3.00, 95% CI: 0.97–9.30, result not shown) and stomach (four cases, RR: 2.19, 95% CI: 0.82–5.84) cancers as well as multiple myeloma (two cases, RR: 3.94, 95% CI: 0.98–15.77, result not shown) while none of these excesses were observed among veterinarians.

The small numbers of other neoplasms, such as eye cancer and CNLL, found at increased risk in the broad group of veterinarians and employees of the veterinary industry (Table 3) hampered the analysis by specific occupational groups.

Table 5 compares veterinarians with individuals of similar socio-economic status. This analysis confirmed the increased incidence of esophageal, colon, pancreatic and brain cancers as well as melanoma of the skin among veterinarians.

Discussion

We found a statistically significant increased risk of esophageal, colon and brain cancers as well as melanoma of the skin and a non-significant elevated risk of pancreatic cancer among Swedish veterinarians employed in the veterinary industry. Except for colon cancer, these results were confirmed among veterinarians employed in other industries.

The excess risks observed when veterinarians were compared to all non-veterinarians, whatever their socio-economic status, were similar to those obtained when they were compared to individuals of similar socio-economic status.

A quite different pattern was observed among the non-veterinarians employed in the veterinary industry. They experienced increased risks of oral, stomach, and prostate cancers as well as melanoma of the skin and multiple myeloma.

The present study has several advantages. It was based on a cohort of Swedish male veterinarians and other workers of the veterinary industry with almost complete follow-up for cancer incidence. Only one other study has provided results on cancer risks among European veterinarians [8] and the present study is the only one based on cancer incidence. The main limitations of our study concern lack of information on specific exposures and on potential confounding factors such as tobacco smoking, alcohol drinking, and other lifestyle factors. Nevertheless, since alcohol consumption and tobacco smoking are more common in lower than in higher social strata [12, 13], tobacco smoking and alcohol drinking should not be strong positive confounders in the occupational group of interest.

We observed an increased risk of esophageal cancer among veterinarians that was not reported in previous studies of this occupational group [3–8], but was previously reported among workers in poultry slaughtering plants [14] and abattoirs or meatpacking plants [15]. It has been suggested that exposure to oncogenic viruses may be a possible explanation for the elevated cancer risks observed in the meatpacking industry [15] and papillomaviruses have been raised as potential candidates as etiologic agents of esophageal cancer in cattle and humans [16]. We are not aware of data on alcohol and tobacco consumption among veterinarians, but like physicians, who consume less tobacco [17, 18] and have a lower risk of having alcoholism listed as a hospital discharge diagnosis [12] than other occupational groups, we do not suspect the confounding by tobacco and alcohol consumption are likely explanations for the excess of esophageal cancer among veterinarians.

The elevated risk of colon cancer we observed corroborates the findings of two previous cohort studies [3, 4]. Colon cancer has been associated with exposure to ionizing radiation, especially among highly exposed subjects, such as atomic bombs survivors [19]. Exposure to ionizing radiation, however, does not seem to be a likely explanation for the increased risk of colon cancer we observed among veterinarians, since we did not find an elevated risk of leukemia, a malignancy known to be associated with radiation at relatively low doses [20]. Socio-economic factors might have contributed to the increased incidence of colon cancer. On the other hand, the excess persisted when veterinarians were compared with non-veterinarians of high socio-economic status, which suggests that socio-economic confounding may not be the explanation.

The increase in pancreatic cancer experienced by the veterinarians in the present study was not observed in previous studies [3, 4, 21]. Such an excess has been reported among anesthetists [22], but not others [23]. Therefore, chance cannot be ruled out from the possible explanations for the association we found.

The excess of melanoma of the skin, observed in our study has been also reported in previous studies. Indeed, Fasal *et al.* [6] and Miller and Beaumont [4] reported an increase in melanoma of the skin while Blair and Hayes [3, 21] reported an elevated risk of skin cancer (for both melanoma and non-melanoma combined). Possible explanations for the increased incidence of skin melanoma include mainly socio-economic factors [24] and solar radiation [25]. For solar radiation, a recent study based on Swedish data found that occupational sun exposure was not associated with the risk of developing skin cancer (melanoma and non-melanoma) [26] corroborating the findings of a previous review [25]. Furthermore, in the present study the cases of skin melanoma observed among veterinarians, occurred mainly on the covered parts of the body (seven melanoma of the trunk out of eight melanoma observed) and not on the parts (lip, face, neck and arm) that are most commonly exposed to sunlight during work. These results detract plausibility from solar radiation, due to occupational outdoor exposure, as an explanation of the excess of skin melanoma observed in our study. Nevertheless, as an elevated risk of skin melanoma was also observed when veterinarians were compared to subjects with highest income and education, this excess does not seem to be explained by socio-economic factors only.

The increased risk of cancer of the brain and nervous system observed in the present study was already reported by Blair and Hayes [3, 21], while Miller and Beaumont [4] found no evidence that veterinarians have an increase in death from central nervous system cancer. A trend of increasing incidence of brain cancer with increasing social class is known [27], but we observed elevated RR among veterinarians even when they were compared to other workers of high socio-economic status. Increased risks of brain and nervous system cancers have been reported in other health professions and in agriculture workers [27]. Nevertheless, while specific exposures underlying these associations have not been established [27], the excess observed in the present study may reflects specific, although as yet unidentified, occupational agents.

Previous studies found an excess of lymphohaematopoietic neoplasms [3, 4, 21, 28, 29] possibly due to the exposures experienced by veterinarians, including ionizing radiation, anesthetics, insecticides and animal viruses [2]. However, we did not observe a consistent increase in the risk of lymphohaematopoietic neoplasms in our study. Our negative result may be explained by differences in exposure circumstances between North America and Sweden.

Among non-veterinarians employed in the veterinary industry, who were mainly agricultural workers, we observed increased risks of oral, stomach, prostate and skin cancers as well as multiple myeloma, while decreased risks were found for cancers of respiratory organs, colon and bladder. Although most results were based on small numbers not statistically significant, they resembled the cancer pattern observed among farmers [30].

In conclusion, the present study based on cancer incidence found increased risks of melanoma and colon and brain cancers as previously reported in mortality studies of veterinarians in the United States. The present study found also an increased incidence of esophageal and pancreatic cancers. These excesses were not explained by the high socio-economic status of veterinarians, because they persisted when we compared veterinarians to other high income and education groups. Chance remains a plausible explanation for some of our results, since we performed many comparisons between veterinarians and other individuals. It is plausible, however, that some of these results reflect the carcinogenicity of occupational exposures, including animal viruses, solar or ionizing radiations and anesthetics. The attribution of specific results to specific agents, however, remains only speculative.

Acknowledgements

We acknowledge Heather Clancy of Information Management Services, for the computer programming. Noemie Travier worked on this study under the tenure of a Special Training Award from the International Agency for Research on Cancer.

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